COMPARISON OF CHEMICAL SOLVENT FOR CO_2 REMOVAL FROM POWER PLANT USING AMINE SCRUBBING PROCESS

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ABSTRACT

This research is aims to compare monoethanolamine (MEA), diethanolamine (DEA), and N-methyldiethanolamine (MDEA) solvents to achieve higher CO_2 removal efficiency in absorber column by varying some process parameters including amine concentration, lean solvent flow rate and temperature. Process model was developed using Aspen Plus v12.1 with the electrolyte property inserts for each amine using electrolyte-NRTL thermodynamic model. The rate-based Radfrac absorber column are model by using data adapted from pilot plant data Case 32 at University of Texas, Austin by Dugas (2006). From the results obtained, it showed shows that the CO_2 removal efficiency is increased with increasing of amine concentration for each amine. The CO_2 removal efficiency using the MEA solvent is the highest compared than DEA and MDEA solvent. Besides that, it is more realistic to used MEA concentration not more than 31.5 wt. % as it can achieved 99.8% CO_2 removal efficiency and to avoid corrosion effect to equipment in real plant. As the lean solvent flow rate increases, the CO_2 removal efficiency for studied amines increases that can be arranged as the following order: MEA > DEA > MDEA. MEA shows high CO_2 removal efficiency because MEA is primary amine which has high CO_2 absorption capacity and reactivity than to DEA and MDEA. However, CO_2 removal efficiency was decrease as lean solvent temperature increase for all amines. This is due to the reduction of amine in lean solvent since it were vaporised before entering the absorber. MEA solvent can achieved approximately 99% CO_2 removal at 1 kg/s lean solvent flow rate. While the DEA and MDEA can achieve 99% CO_2 removal efficiency around 133 kg/s and 110 kg/s lean solvent flow rate respectively. It proved that the MEA can achieve very high CO_2 removal efficiency at low lean solvent flow rate and concentration compared to DEA and MDEA.

Keywords: power plant, absorber model, CO_2 removal, amine solvent, Aspen Plus.

ABSTRAK

Kajian ini adalah bertujuan untuk membandingkan monoethanolamina (MEA), dietanolamina (DEA), dan N-methyldiethanolamina (MDEA) pelarut untuk mencapai kecekapan penyingkiran karbon dioksida (CO_2) yang lebih tinggi dengan mengubah beberapa parameter proses termasuk kepekatan amina, kadar aliran 'lean solvent' dan suhu. Simulasi proses dilakukankan menggunakan Aspen Plus v12.1 dengan memasukkan elektrolik bagi setiap amina yang model termodinamik elektrolik-NRTL. 'Radfrac absorber' simulasi dilakukan berdasarkan model dengan data disesuaikan dari 'pilot plant' kes data 32 di Universiti Texas, Austin oleh Dugas (2006). Daripada keputusan, ia menunjukkan bahawa kecekapan penyingkiran CO_2 telah meningkat dengan peningkatan tumpuan amina untuk setiap amina. Ia dilihat bahawa kecekapan penyingkiran CO_2 menggunakan pelarut MEA yang adalah yang tertinggi daripada pelarut DEA dan MDEA. Selain itu, adalah lebih realistik untuk MEA tidak kepekatan digunakan lebih daripada 31.5 wt.% kerana ia boleh dicapai 99.8% kecekapan penyingkiran CO_2 dan untuk mengelakkan kesan hakisan kepada peralatan di dalam loji kuasa sebenar. Apabila kadar aliran 'lean solvent' meningkat, kecekapan penyingkiran CO_2 untuk amina yang dikaji boleh disusun sepertiyang berikut: MEA > DEA > MDEA. MEA menunjukkan tinggi kecekapan penyingkiran CO_2 kerana MEA adalah 'primary amine' yang mempunyai kapasiti penyerapan CO_2 yang tinggi dan kereaktifan daripada DEA dan MDEA. Walau bagaimanapun, kecekapan penyingkiran CO_2 adalah menurun apabila suhu kadar aliran 'lean solvent' meningkat untuk semua amina. Ini adalah disebabkan oleh pengurangan amina dalam kadar aliran 'lean solvent' kerana ia telah diwapkan sebelum memasuki penyerap. MEA boleh pelarut mencapai kira-kira 99% penyingkiran CO_2 pada 1 kg / s kadar aliran 'lean solvent'. Walaupun DEA dan MDEA boleh mencapai 99% penyingkiran CO_2 kecekapan sekitar 133 kg / s dan 110 kg / s bersandar kadar aliran pelarut masing-masing. Ia membuktikan bahawa MEA boleh mencapai kecekapan penyingkiran CO_2 sangat tinggi pada rendah kadar aliran 'lean solvent' dan kepekatan berbanding dengan DEA dan MDEA.

Keywords: loji kuasa, model penyerap, penyingkiran CO_2, pelarut amina, Aspen Plus.

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$\dot{m}^{fluegas}$	flue gas flow rate
$\dot{m}^{solvent}$	solvent flow rate
$T^{fluegas}$	flue gas temparature
$T^{solvent}$	lean solvent temperature
wt.	weight
x_{amine}	amine concentration

LIST OF ABBREVIATIONS

CCS	Carbon capture and storage
CFC	Chlorofluorocarbon
CH_4	Methane
DEA	Diethanolamine
EOR	Enhances oil recovery
GHG	Greenhouse gases
IGCC	Integrated Coal Gasification Combined Cycle
IPCC	Intergovernment Panel on Climate Change
MEA	Monoethanolamine
MDEA	Methyldiethanolamine
NRTL	Non-random-two-liquid
SFC	Sulfur hexafluoride
TWh	Terawat hours
USD	United Stated Dollar

1 INTRODUCTION

1.1 Background

The "Three E's" stand for energy, economy and environment which are all societies concerned. People need energy particularly to generate electricity to improve standard quality of life, increase economic status and at the same time living in clean environment. Societies living with electricity, peoples drink cleaner water, live longer and have better education. Besides that, energy also can transform agrarian societies to modern industrial societies by increases their income and wealth. This can prove by industrial country such as in United States and Western Europe which use fuels to improve their socio-economic (IEA, 2012).There are four macro trends which are industrialisation, urbanization, modernisation and electric information revolution which are the criteria of modern industrial societies. These macros have required high demand for energy for transportation, manufacture products and transfer information. Urbanisation is the main factor that drives high demand of energy due to increase the proportion and population of people living in cities (IEA, 2012).

The energy supply, particularly electricity must be enough to fulfil the demand of electricity required for maintain socio-economic worldwide development. Fossil fuels including coal, natural gas and oil are contributed about 81% of world's primary energy demand (IEA, 2012). Coal is main fossil fuels generating electricity compared to natural gas and oil over the past decades. Electricity produced by coal is over 8200 terawatt hours (TWh) annually which is about 41.3% of the world's power as show in Figure 1.1. Furthermore, additional of 3800 TWh contribute 44% of coal generating electricity by 2035.

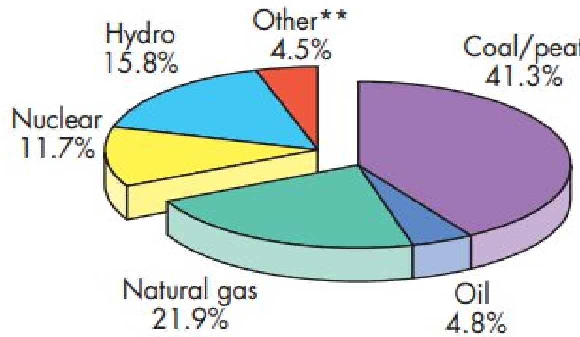

Figure 1-1: 2011 electricity generation by sources (IEA, 2013)
**Other includes geothermal, solar, wind, biofuels and waste, and heat

If compare among fossil fuels, coal give low energy prices which enables produce inexpensive electricity. In China, electricity generating from coal is the most affordable sources which costing USD 33/ MWh compared to USD 71 for wind, USD 50 for hydro and USD 53 for nuclear (IEA, 2010). Additionally, energy produced by coal have equivalency basis than natural gas and oil (IEA, 2012). Since coal is most abundant and widely distributed fossil fuel, the amount of electricity generated from coal is exceeds coal capacity compared to other fossil fuels.

Global climate changes know as global warming is a serious environmental issue which are most of people concern and become global problem. Global warming is caused by greenhouse gases (GHGs) in earth atmospheres that trap heat from reflected back to space. CO_2 is proven as the most abundant greenhouse gas that has caused increasing of earth's surface temperature and climate changes than others GHGs like CH_4, SF_6. N_2O, and CFC's (IPCC, 2005). The main source of CO_2 is from flue gases exhausts from burning of fossil fuels in boilers and furnaces that emitted from large exhaust stacks (Table 1.1). Besides that, large point sources of CO_2 are concentrated in proximity to major industrial and urban areas which use coal as generating electricity (IPCC, 2005).

Table 1-1: CO_2 emission by process (IPCC, 2005)

Process	Number of sources	Emissions ($MtCO2\ yr^{-2}$)
Fossil fuels		
Power	4,942	10,539
Cement production	1,175	932
Refineries	638	798
Iron and steel industry	269	646
Petrochemical industry	470	379
Oil and gas processing	Not available	50
Other sources	90	33
Biomass		
Bioethanol and bioenergy	303	91
Total	7,887	13,468

As the awareness and responsibility towards the environment, there are some options can be taken to reduce CO_2 emissions from power plant such as using advanced fossil-fuel technologies to increase coal-based generation efficiency and coupled with capturing and storing (CCS) CO_2 exhaust from combustion of fossil fuels. The benefits from these options can sustain coal as primary energy source and help reduce global warming. There are three types of CO_2 captured system for power plant such as post-combustion, pre-combustion and oxy-combustion. However, these technologies still in pilot plant stage and not applied yet in existing commercial power plant. There are several CO_2 capture technologies available such as chemical and physical absorption, adsorption, cryogenic and membrane separation. The key of selection for CO_2 system and technology are depending on energy efficiency, capital cost, and performance in plant.

According to Herzog et al. (2000). shown that absorption process based on chemical solvents are currently the preferred option for post-combustion CO_2 capture and suitable for fossil fuels power plant. Advantage of post combustion process technology is it can retrofitted to existing fossil-fuel power plant with less capital investment compare to pre-combustion and oxy-combustion. Besides, this process is suitable for treating high-volume gas stream containing H_2S and CO_2 at low partial pressure (Kohl and Nielsen, 1997). Amine solution is chemical solvents that used for many years for removal CO_2 from natural and synthesis gases because the maximum removal CO_2 can be achieved.

1.2 Motivation and problem statement

Amine scrubbing process had proven as most preferred technology used to CO_2 removal in post combustion for many reasons. Amine solvent can achieve high CO_2 absorption about 90% when the gas is to be treated at low pressure, typically 3-15kPa (Kohl and Nielsen, 1997; Rao and Rubin, 2002). Additionally, amine solvent has low capacity and high alkalinity.

However, the existing chemical solvent used in this process give contribute to some drawback to such as high corrosion rate to equipment, low CO_2 loading capacity , and chemical losses. Corrosive is serious problem when using amine solvent in gas purification which gets most of the attention and many extensively studied available to eliminate corrosion issued. MEA is proven as most corrosive chemical solvent than other amine-based solvents (Kohl and Nielsen, 1997). The corrosion in amine plant including; wet acid gas corrosion occur in overhead section of stripper and bottom section of absorber, amine solution carbon steel corrosion occur in the bottom section of stripper. Wet CO_2 corrosion happen when increase in hydrogen ion concentration in ionization of CO_2 dissolve in water. So, the rate of corrosive increase with increases CO_2 concentration in the water. Amine solution carbon steel corrosion is cause by amine type. Primary and secondary amine can give corrosive since they can form carbamate when react with CO_2 than tertiary amine (Kohl & Nielsen, 1997).

Chemical losses of existing amine solvent, especially MEA which has higher vapour pressure than other amine and volatility losses can happen in low pressure in absorber (Figure 1.2).Besides that, amine degradation is another factor of chemical losses in existing amine plant. Solvent degradation is around 10% of total cost of CO_2 capture (Rao and Rubin, 2002).There are two types of degradation occur in existing fossil-fuel power plant which are thermal degradation occur due to presence of CO_2 at high temperature and high pressure in stripper and oxidative degradation occur if high amount of O_2 present in flue gas in absorber. In case of MEA, ammonia, N-(2-hydroxyethyl)-2-(2-hyroxyethylamino)-acetamide (HEHEAA) and N-(2-hydroxyethyl)-

piperazin-3-one (HEPO) are main degradation product in pilot plant (Gouedard et al., 2012). Degradation products can give advantages such as increase solution viscosity, decrease amine solution absorption capacity and in some case can contribute amine corrosive (Kohl and Nielsen, 1997).

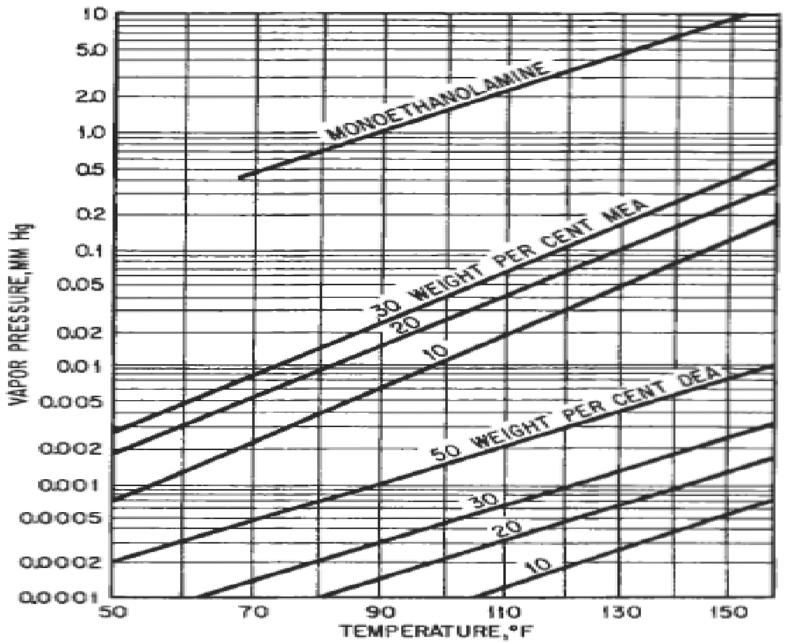

Figure 1-2: Vapor pressure of MEA and DEA at varies temperature

(Kohl and Nielsen, 1997)

All these problems will lead to high energy demand required for solvent regeneration which reduces the plant efficiency. Besides that, these problems will reduce the CO_2 removal efficiency in absorber and vented gases will increase GHG emission to atmospheres. Therefore, improvement in chemical solvent development is crucial for achieve higher CO_2 removal, reduce corrosive and decrease chemical losses. Besides, output from absorber can affect amount of energy required for amine degradation in stripper. Moreover, each of amine solvent has different reactivity at different parameter such as column pressure. Solvent flow rate and amine concentration also can give effect on efficiency of CO_2 removal in absorber. Thus, three types of chemical solvent which are alkanolamines; MEA, DEA and MDEA are chosen in this study to find which one is the best for higher CO_2 removal in post combustion. Main focus in this study is absorber column which to achieve higher efficiency of CO_2 removal by varying some process parameters (amine concentration, lean solvent flow rate and temperature).

1.3 Objectives

The following are the objectives of this research:

- To compare the performance of absorber column to remove CO_2 from power plant using different types of amine solvent using Aspen Plus® software.

1.4 Scope of this research

The following are the scope of this research:

i) Modeling of absorber for CO2 removal from coal power plant using amine scrubbing process based on the pilot plant study which done by Dugas (2006).

ii) Analyse the effect of amine concentration, lean solvent flow rate and temperature of MEA, DEA and MDEA on the efficiency of CO_2 removal.

The process flow diagram which stand-alone absorber is same as in Alie et al. (2005) and the flue gas flow rate and composition is used from Notz et al. (2012) based on the post combustion pilot plant study. Thermodynamics and transport properties were modelled by using amine concentration in Aspen Plus (Alie et al., 2005, Abu-Zahra et al., 2006). In this study, three difference types of amine solvents are used; MEA, DEA and MDEA to find the highest percentage of CO_2 removal in absorber. The concentration of amine solvent, lean solvent flow rate and temperature of each amine are set as process parameters variation used in this study. All these process parameter variations were used to find the efficiency of CO_2 removal in amine scrubbing process.

1.5 Organisation of this thesis

The structure of the reminder of the thesis is outlined as follow:

Chapter 2 present about review from previous literature related to CO_2 capture process in post-combustion technology. This chapter also describe in details about amine scrubbing process. Other than that, literature review about amine based-solvent and its chemistry and chemical kinetics also discussed in this chapter.

Chapter 3 describes the simulation algorithm used in this study. The operating conditions and column specification are including in this chapter. This chapter also gives overview about process parameter variation in this study.

Chapter 4 present the model validation for this simulation. Besides that, this chapter also shows the result and discussion based on the results obtained.

Chapter 5 gives a conclusion of the result and discussion which obtained from the Chapter 4.

2 LITERATURE REVIEW

2.1 Overview

This chapter are divided into six sections and organizes as follow: In Section 2.1 gives an overview of CO_2 emissions. Section 2.2 provides the potential of CO_2 capture technology for power plant including post combustion, oxy fuel combustion and pre combustion. While in Section 2.3 gives a description on advanced Post-combustion CO_2 capture. In section 2.4 an overview about amine scrubbing process. Meanwhile, section 2.5 briefly describes amine based-solvent and its chemistry and chemical kinetics. Lastly, section 2.6 provides overview about Aspen Plus simulator programme.

2.2 Carbon Dioxide Emission

Carbon Dioxide (CO_2) is proven as most abundant greenhouse gas that has caused increasing of earth's surface temperature and climate changes (Desideri and Poalucia, 1999; IPCC, 2005). About 77% of CO_2 emissions contribute to greenhouse gases composition and 74% from that are contribute from fossil fuel combustion (Figure 2.1).The increasing earth temperatures can result the world being affected by droughts and also harming agricultural production. According to United Framework Convention on Climate Change (UNFCCC, 2006) Conference, average global temperature increase must be held below 2 degrees Celsius (°C) to avoid worst impact of climate change .The maximum greenhouse gases concentration in earth atmospheres to achieve 2°C is 450 parts per million (ppm) of carbon-dioxide equivalent (IEA, 2013).

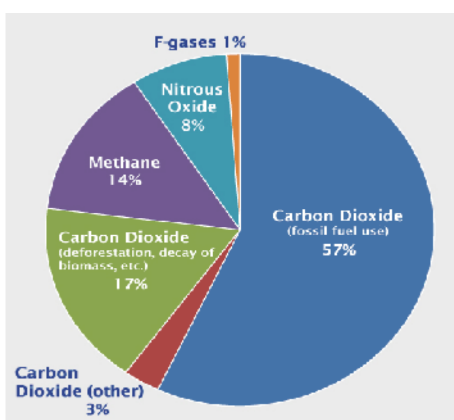

Figure 2-1: Global greenhouse gas (IPCC, 2007)

Combustion of fossil fuel power plant is main source of CO_2 emission to atmospheres compared than to industrial processes and natural gas processing. CO_2 emission contribute from coal fired power plant is higher than natural gas and oil combustion (Figure 2.2). The control of this greenhouse gases is the most concern in environmental policy issue in worldwide. Carbon capture and storage (CCS) is one of most suitable mitigation option to reduce CO_2 concentration in atmospheres and fulfil continual use of carbon-based fuels to meet the world's growing energy demand. CCS is possibly to decrease total energy related CO_2 emissions from 36 percent in 2005 to 34 percent in 2040 (IEA, 2013). CO_2 from flue gases produced by combustion of fossil fuels will extract using CO_2 recovery system. This system will produce concentrated CO_2 and will be stored in disposal site such as underground or used in food, chemical industries and enhances oil recovery (EOR) rather than emitted to atmosphere (Chapel et al., 1999; IPCC, 2005).

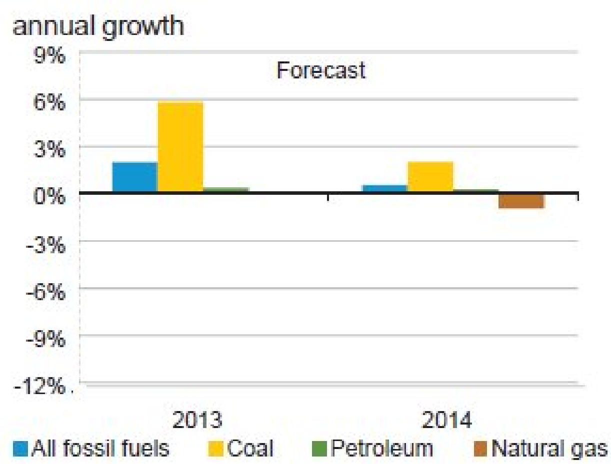

Figure 2-2: United Stated Carbon Dioxide emission by fossil fuel (Short-Term Energy outlook IEA, 2013)

2.3 CO2 capture technologies

Although the CO_2 technologies has not been applied at large-scale power plants, but there are wide range of technologies exits for CO_2 removal (IPCC, 2005). Figure 2.3 show four types of CO_2 capture system; post combustion, pre combustion and oxy-fuel combustion (Rao and Rubin, 2007; IPCC, 2005). The selections of CCS technology are based on performance of CCS technology used, the condition of flue gas which depends on the power plant technology and also the capital cost (Chakravarti et al., 2001). The most cost-effective levels of CO_2 capture efficiency were estimated to be 81% for 1000 MWg power plant (Rao and Rubin,2006). The best practical use of CCS technology is by retrofitted or add-on to the existing power plants which without modify the current infrastructure.

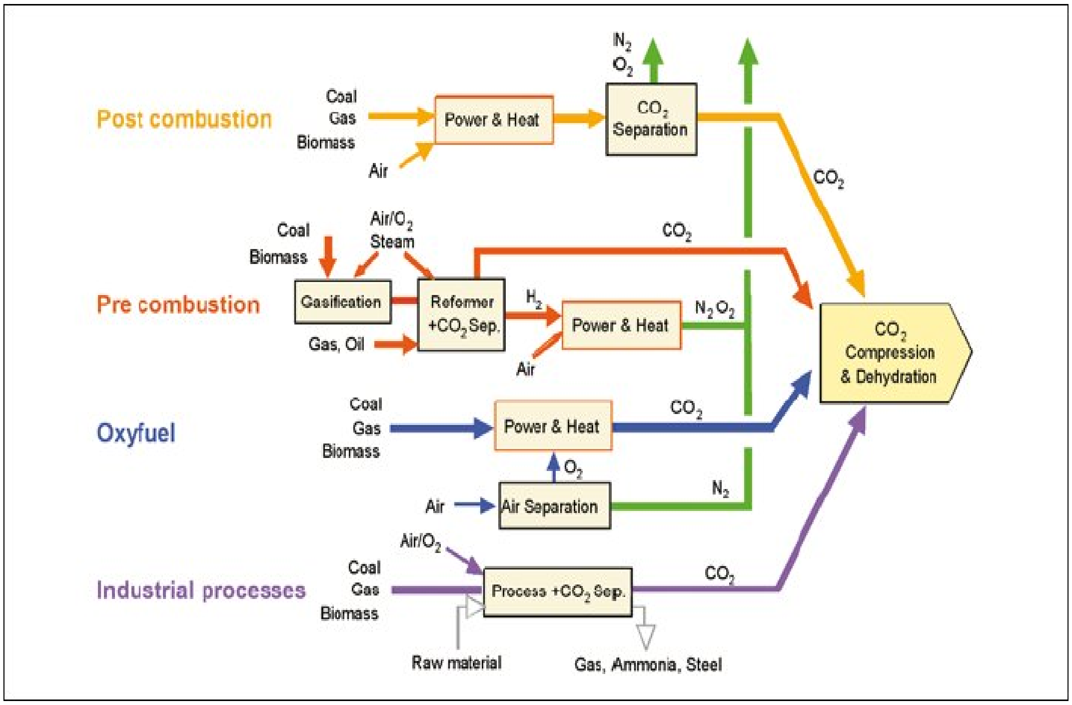

Figure 2-3: Carbon dioxide capture systems

2.3.1 *Post combustion*

In post combustion technology, CO_2 is captured from the flue gas exhaust by combustion of fossil-fuels in air (Figure 2.4). The CO_2 recovery system will absorbed CO_2 from flue gas that pass through it. The captured CO_2 is sequestration and the free CO_2 is discharged to atmosphere. The flue gases produced from combustion of fossil fuel is at atmospheric pressure which low pressure resulting large amount of nitrogen present in air. Hence, the large scale of CO_2 recovery unit needed which required higher capital cost. Chemical solvent process is commonly used for CO_2 removal in post combustion technology. A large amount of thermal energy required in this process to regenerate solvent and resulting reduction the efficiency of power plant. Even though the chemical solvent process in post combustion technology more problematic than other technology, it most common technology use which give high CO_2 capture efficiency and selectivity (IPCC, 2005). Besides that, post combustion technology still preferred technology to remove CO_2 since this process is reliable and well proven.

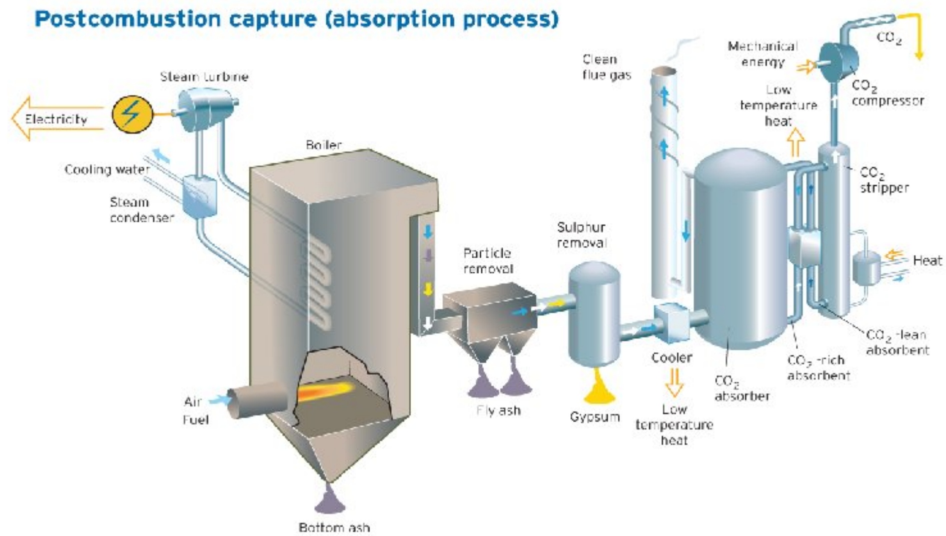

Figure 2-4: Post combustion technology

2.3.2 Oxy fuel combustion

Mechanism of oxy fuel combustion technology is same as in post combustion technology, but pure oxygen is used for combustion instead of air. By doing this, the composition of flue gas produced from combustion of fossil fuel mainly 80-98% CO_2 and H_20.Thus, CO_2 recovery system not required in this technology and CO_2 is directly to CO_2 compression process. Oxygen produced in air separation with low temperature which is cryogenic and other techniques including membranes and chemical looping cycles (IPCC, 2005). Disadvantages of this process is high temperature produced about 3500°C when combustion of fossil fuels and pure oxygen. Thus, the typical power plant material such as gas turbine cycle operates at 1300°C - 1400°C cannot be matched with the process. Water cooling is needed in the combustion chamber to control the temperature. CO_2 removal using oxy-fuel combustion is not commercial yet.

2.3.3 Pre combustion

In pre-combustion technology, fossil fuel is reforming to produce synthesis gas or syngas by reacting fossil fuel with oxygen or air and/or steam. The syngas is composed of hydrogen and carbon monoxide. Carbon monoxide is converted to CO_2 in a catalytic reactor by reacting CO with steam. Next, the CO_2 can be captured and storage, while hydrogen is combusted to produce power. CO_2 in pre-combustion is captured and storage before the combustion process. Pre-combustion technology usually used physical and chemical absorption to remove CO_2 and high concentration hydrogen are used as fuel for gas turbines, boilers and furnaces. Integrated Coal Gasification Combined Cycle (IGCC) is technology for new power plants where coal is converted or gasified into CO_2 and H_2 before combustion. Advantages of IGCC are low levels of air-pollutant emission since the pollutants are captured before combustion, low process stream volume and can operate at high partial pressure. However, IGCC are not widely implemented in CCS because it only relevant to new power plant, not matured as post-combustion technologies and high capital cost than pulverized coal power plant (IPCC, 2005; Chakravarti et al., 2001).

2.4 Advanced Post-combustion CO2 Capture

Varieties of processes and improvement have been developed over the years to treat certain of gas with the aim of optimizing capital cost and operating cost and for environmental purpose. A lot of CO_2 recovery from flue gas technologies currently exists such as membranes, absorption, adsorption and cryogenic (Rao and Rubin, 2007; IPCC, 2005). Adsorption, membranes and cryogenics separation technologies are exist, but they not economically viable for CO_2 removal from flue gases in post combustion power plant. In adsorption process, CO_2 are adsorbed to activated carbon and desorbing of CO_2 by using pressure swing operation. This process not deployed in CO_2 removal from flue gas but commercial in hydrogen production from synthesis gas. Whereas, membrane process is operated at high CO_2 concentration and high pressure which not compatible with low partial pressure and low concentration of CO_2 from flue gas. This will reduce the driving force for CO_2 separation in membrane process (IPCC, 2005). There are two types of absorption available for CO_2 removal in post-combustion power plant which is chemical and physical absorption. The selection of separation process for CO2 removal is depend on the flue gas characteristics (Chakravarti et al., 2001).Typical composition of flue gas emitted from coal-fired power plant is 14% CO_2, 5% O_2 and 81% N_2 at low pressure which above atmospheric pressure (Chakravarti et al., 2001).Chemical absorption process is currently preferred process for CO_2 removal in post-combustion since the CO_2 from flue gases is diluted and low partial pressure (IPCC, 2005; Kohl and Nielsen, 1997).

2.4.1 Physical Absorption

In physical absorption is occurring at low temperatures and high pressures (>200psia) and suitable for high partial pressure CO_2 from natural gas. Besides, CO_2 are absorbed into solvent on Henry's law (Lawal et al, 2009). The CO_2 absorb into soluble solvent and does not react chemically with solvent. This process is not convenient for flue gas because of low driving force of separation that gives low CO_2 removal. According to Chakravarti et al. (2001), high amount of energy required to compress which mostly composed of N_2 gas if physical absorption used in CO_2 removal from flue gas. Example of solvent used in physical absorption process is polyethylene glycol dimethyl ether in Seloxol Process (Kohl and Nielsen, 1997).

2.4.2 **Chemical Absorption**

Chemical reaction involve in chemical absorption is well applicable for CO_2 removal from flue gas. The chemical reaction can enhance the driving force of separation of CO_2 from flue gas to chemical solvent even at low CO2 partial pressure (60-100 psia). Besides that, the higher CO_2 removal efficiency can be achieved by this process. CO_2 purity (>99%) vapour can be obtain show that chemical absorption is most effective CO_2 removal from flue gas (Chakravarti et al., 2001). Chemical solvents which suitable for captured CO2 from flue gas at low partial pressure is aqueous solution chemicals. According to Kohl and Nielsen (1997), amines based solvent is most widely and reliable as chemical solvent known as amine absorbing or amine scrubbing process.

2.5 Amine scrubbing process

Amine scrubbing process is one of the chemical absorption processes which using amine liquid as solvent to remove CO_2. The high percentage of CO_2 removal can be achieved by this process between 80%-95%.The unit operations used in this technology consist of absorption packed and stripping column and the process is continuous (Figure 2.5).

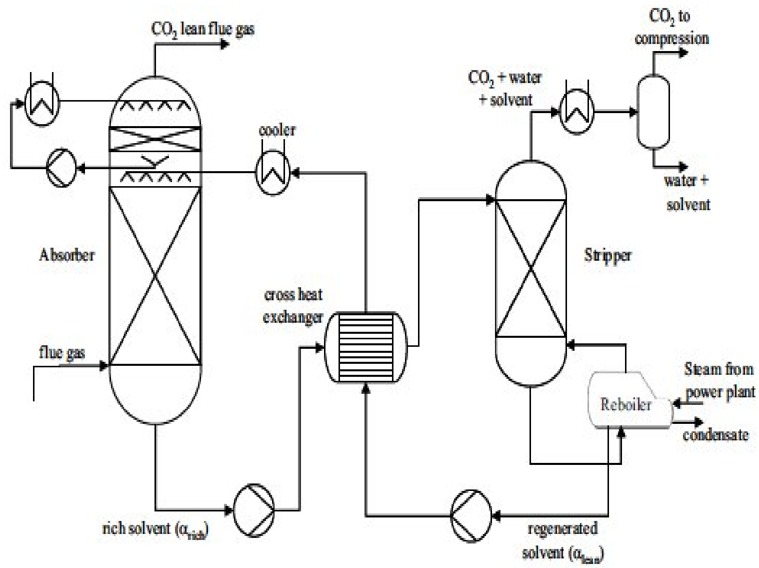

Figure 2-5: Typical process flow diagram for amine scrubbing process from flue gas

Treatment on flue gases is needed to remove acid gas such as NO_x and SO_x that can reduce absorption efficiency by forming heat stable salts with amine solvent (Lawal et al.,2009). Flue gas is cooled to 45-50°C before enter the absorber to increase CO_2 absorption and reduce solvent loss. Treated flue gas enters at the bottom of absorber and lean amine solvent enters from the top of absorber to allow counter-current flow. The temperature of solvent increase as absorbs CO_2 from flue gas which the reaction is exothermic. Temperature of top absorber is between 40-45°C and 50-60°C at the bottom absorber. CO_2 from flue gases absorbed and react chemically with lean amine solvent counter currently in the absorber. The absorption process is exothermic reaction and typical temperature of absorber is low between 40°C-60°C (IPCC, 2005; Cheng et al., 2012). Washing section at top absorber maybe required to reduce water loss and free CO_2 gases are vented to atmospheres.

2.6 Amine based Solvent

Amine compound are characteristic by presence of amino group (-NH_2) attach in hydrocarbon chain and water-soluble organic chemicals. Amines are divided into primary, secondary and tertiary amines which depend on hydrogen attached to nitrogen atom. Amine is solubility to acid gases because they are bases. Selection of amine solvent is important because it will affect percentage of CO_2 removal and its